Calculating Power

When electric charges move through a circuit, potential energy is converted to other forms of energy. The *rate* at which this energy is converted is defined as the **power** used. As an equation,

$$\mathbf{P = \frac{\Delta E_p}{t}} \qquad \rightarrow \text{recall from energy unit}$$

$\rightarrow$ but also recall that $\mathbf{\Delta E_p = qV}$ so $\mathbf{P = \frac{qV}{t}}$

$\rightarrow$ and, since $\mathbf{\frac{q}{t} = I}$, by substitution we get $\boxed{\mathbf{P = IV}}$

This is the general formula for power transformed by any electrical device, measured in *watts* (W).

The rate of energy transformation in a resistance **R** can also be written in two other ways. By substituting Ohm's Law,

$$\mathbf{P = I^2R} \qquad \text{and} \qquad \mathbf{P = \frac{V^2}{R}}$$

Example #13: From the circuit diagram for example 11, calculate the power used by each resistor connected in the circuit.

(see Circuitry Ex 13 for answer)

Since electrical devices use electrical energy, we can find the cost of using electrical devices. However, the basic unit of energy (the joule) is very small for this purpose, so we use a larger unit called the *kilowatt hour* **(kWh)**. The cost of electricity then is found by:

$$\begin{aligned}\mathbf{Cost} &= \mathbf{Energy \bullet rate} \\ &= \mathbf{Pt \bullet rate} \\ &= \mathbf{IVt \bullet rate}\end{aligned}$$

Example #14: Find the cost of operating a kettle for 15 min if it draws 10 A from a standard 120 V outlet, and the cost is 5.5¢/kWh.

(see Circuitry Ex 14 for answer)

Example #15: An electric fan draws 2.0 A of current from a 120 V source. Determine the following:

(a) the power rating of the fan.
(b) its electrical resistance.
(c) the cost of operation of the fan during the month of August, assuming it is run continuously and electric energy costs 10 cents per kilowatt hour.

(see Circuitry Ex 15 for answer)

Finally, note that electrical energy and power can be converted to other forms of energy and power. Electrical energy, which is given by $\Delta E = Pt$ (where $P = IV$), can be equated with:

$$\Delta E = Fd \qquad \Delta E = mg\Delta h \qquad \Delta E = \frac{1}{2}m(v_f^2 - v_i^2)$$

Example #16: A 6.0 volt motor is used to winch a 0.056 kg mass a vertical distance of 0.65 m in 5.62 sec. What current will the motor draw?

(see Circuitry Ex 16 for answer)